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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
DENVER, CO 80202-1129
Phone 800-227-8917
http://www.epa.gov/region08

Ref: 8EPR-ER

September 17, 2013

Mr. Anthony Brown
Atlantic Richfield Company
4 Centerpointe Drive
Project Manager, Mining La Palma, CA 90623-1066

Re: Rico Argentine Mine Site – Administrative Order for Removal Action ("UAO")
Docket No. CERCLA-08-2011-0005: EPA Comments on the St. Louis Tunnel Discharge Constructed Wetland Demonstration Treatability Study Work Plan

Dear Mr. Brown:

The following comments and discussion are provided on the *St. Louis Tunnel Discharge Constructed Wetland Demonstration Treatability Study Work Plan* (Work Plan) submitted by Atlantic Richfield Company (AR) to EPA on August 13, 2013. These must be addressed as part of the task to evaluate water treatment technologies, and a written response to these comments is required.

## Pilot-Scale Passive Treatment Test Results

A description of the results from evaluating the pilot-scale wetland is provided in the Work Plan section 2.2. This section addresses some of the topics that would be addressed in a final report of the results but it has minimal backup information. The pilot-scale wetland report needs to be submitted to EPA. Several observations regarding the pilot-scale test data include:

- The average pH value cited for the pilot-scale test is 8.3 standard units at the Pond 11 discharge/pilot-scale wetland inflow. Please provide an explanation as to whether or not this pH value was influenced by the 517 shaft alkaline injection test given chemical injection may or may not be a component selected for treatment at the site. In addition, the inflow pH values do not appear to match those measured by AECI during their sampling in the same time period.
- Total cadmium (range of 0.22 μg/L to 1.2 μg/L) and zinc (range of 112 μg/L to 316 μg/L) concentrations in the pilot wetland effluent were lower than the State acute WQS for dissolved metals (3.74 μg/L for cadmium and 364 μg/L for zinc, calculated at hardness 247 mg/L), indicating that even if the effluent particulates were to re-dissolve, the zinc concentration would be lower than the acute WQS. The proposed discharge limits identified in the State Water Quality Assessment (WQA) (WQCD 2008) for cadmium and zinc are 2.3 μg/L and 729 μg/L, respectively, again indicating that even if the particulate cadmium and zinc are re-dissolved in

the water, discharge requirements for cadmium and zinc could still be met with the wetland efficiency observed in the pilot wetland.

- Manganese concentrations appeared to increase within the wetland portion of the system, with the wetland effluent concentrations exceeding wetland influent concentrations, even for total metals analysis. It is unclear where the manganese might be coming from or if there is some explanation for the increasing concentrations.
- Section 4.3 describes whitish material seen exiting from the pilot-scale reactor as elemental sulfur and biotic material but it is unclear whether the composition of the material was determined by laboratory analysis or by professional judgment. It is also unclear whether the material was likely generated by the use of sulfur prills or whether the same would be expected without prill addition.

**Objectives**

The stated objectives of the demonstration scale system must include the ability to reduce metals concentrations to meet a target concentration for metals of concern based on a relevant water quality standard, such as the preliminary discharge standards established in the State Water Quality Assessment (Colorado WQCD 2008).

A discussion is needed in the work plan regarding the adequacy of the demonstration scale system performance to evaluate those items identified in the objective.

**Schedule and Timing**

The schedule for system start-up has again moved into the in late fall, which is not conducive to microbial development and growth in a start-up system because of weather conditions. How will the start-up procedures and monitoring be developed to address this condition, especially if freezing conditions develop before the inoculation and start up period?

Explain how winter conditions, including avalanche hazards, are to be addressed to allow adequate system observation and physical access for maintenance.

It is important to see the effects of seasonal changes in flow and water quality (metals concentrations, dissolved oxygen, and other important parameters) and how they might affect a full-scale system. The schedule should include operation of the system during both spring flush and low-flow conditions.

Conducting consecutive/sequential tests on the same biological system biases the results toward the final tests if the system is more mature towards the final testing phase. A more meaningful comparison of varying operating conditions can be made if the system is allowed to adapt prior to testing. Given the system is being installed later in the year than planned, this influence on the results and associated conclusions must be evaluated and discussed in the Work Plan.

Given the conditions that cause plugging, channelized flow, etc. often take years to develop in systems, explain how this short-term testing is likely to identify potential hydraulic problems often associated with wetland based systems.

Continued operation of the demonstration scale system(s) beyond the initial test period needs to be considered if this technology is selected for use in treating St. Louis Tunnel discharges. The demonstration scale unit, if monitored for a longer period, may assist in full-scale system design and identification of potential operational problems.

**Design**

Vertical Flow versus Horizontal Flow Reactors

While passive treatment system designers often develop preferences for a particular type of system based on experience and comfort level, it is important to ensure the system is the best fit for site-specific conditions. There is no discussion of why a horizontal flow system was selected for the anaerobic treatment cell over a vertical flow system and why only the horizontal flow system will be tested in the demonstration study. A thorough analysis may have been performed to compare the applicability of horizontal versus vertical flow wetland reactor, but it is not documented in the Work Plan or in other submittals. The Work Plan or other appropriate technical document needs to provide a comparison of the effectiveness, cost, and functionality of available anaerobic designs so that the demonstration project uses the best available design(s) applicable to the site. Furthermore, it is recommended that a vertical flow BCR demonstration scale system be evaluated concurrently.

The following observations and topics must be considered regarding horizontal flow wetlands and the current proposal for evaluating treatment of the St. Louis Tunnel discharge:

- The main benefit of the horizontal system is generally easier construction and maintenance with the ability to make changes in substrate easier, but these advantages may not outweigh the possible disadvantage of plugging and system failure.
- Horizontal flow reactors, even those with barrier walls, often exhibit short-circuiting for various reasons. What is the backup plan if short-circuiting occurs due to a failure of the barrier wall or other causes, leading to a possible false conclusion that passive treatment is not viable at the site?
- The structure and roots of the cattails will add dissolved oxygen into a needed anaerobic reaction zone.
- This project will not test the potential for possible drying of the substrate in select portions of the anaerobic wetlands, particularly the portions at the edges of the wetland or downstream of the barrier. Drying could reduce the effective hydraulic residence time in the anaerobic portion of the SSF wetland.
- As water rises in the second part of the SSF wetland after flowing under the barrier it will be exposed to colder air temperatures and oxygen at a time when it needs to be kept in an anaerobic condition.
- The overall SSF wetland residence time needed for adequate sulfide precipitation may be greater than anticipated due design factors that reduce the percentage of water volume within the SSF reactor with reducing conditions.
- If the downstream portions of the SSF wetland become less reducing due to a reduction in flow from the barrier, there is the possibility that sulfide will be converted back to sulfate and that the bacteria and other organism populations may shift away from those most beneficial for sulfide precipitation.

- A deeper SSF wetland would increase warmth and the percentage of volume of water with reducing conditions, but groundwater depth may be a limiting factor in depth.
- EPA research has shown some success with white rot fungi added to the surface area of a wetland. They are one of the only aerobic organisms with the ability to degrade wood chips by breaking the cellulose-lignin bonds and freeing the carbon for other cellulose degraders to create short-chained carbon molecules for SRB nutrition.

Vertical flow (VF) biochemical reactors (BCR) are the other alternative and can be designed as up-flow or down-flow systems. The following comments are based on experience with specific BCRs that EPA has work on:

- The advantage of the VF BCR is that the surface always remains under water and the reactor drops the DO faster than horizontal wetlands, leaving an increased reaction zone for anaerobic sulfate reduction.
- BCRs short-circuit much less than horizontal reactors due to design differences and gravitational flow / head pressures.
- If constructed properly, the treatment will use all of the substrate continually and not allow segments of the system to dry out or become less effective.
- A BCR can be insulated against cold temperatures by covering with wood chips and other insulating materials. This also reduces oxidation that would occur at water surfaces exposed to air.
- The area required for a vertical flow system is potentially reduced due to the ability to have more complete utilization of the treatment media.

Temperature

One of the changes made from the previous test to the current design includes a switch in components in order to get the anaerobic reaction cell closer to the portal in an attempt to maintain a higher temperature for the SRB. However, it appears that the current design did not carry this idea forward. The flow time from portal discharge to the flow control structure was not given, but we can assume minutes. Additional points are presented below.

- Despite the intent to minimize temperature loss prior to the sulfate reduction treatment unit, two units precede the SSF wetland in the demonstration project system. Water temperature will drop substantially in the settling basin in open winter air for over 17 hours. The residence time for the SF wetland is not shown, but the additional temperature loss and increased dissolved oxygen (DO) that will result from the SF wetland may far outweigh the benefit in reducing the amount of iron that makes its way to the anaerobic cell.
- The lack of a soil "cover" may decrease temperature and thus the efficiency of the demonstration study wetland SSF relative to the pilot-scale wetland that had a soil layer to support the cattails.
- Testing at other sites indicates that heat tape or balls may make little difference in heat loss.
- System plumbing must be able to withstand winter site conditions.
- A deeper SSF wetland would reduce exposure of water to air.

Surface Flow Wetland

Testing this system is a good idea, but the resulting temperature drop and increase in dissolved oxygen plus the need to maintain two ponds with iron oxyhydroxide sludge may make this unit an unnecessary complication for long-term operations. In a worst-case scenario, the iron remaining after the settling basin will drop in the front of a SSF (or at the top of a vertical flow biochemical reactor) and can easily be removed if it presents an issue. Therefore, it might be wise to install bypass piping to allow testing of the downstream units both with and without the SF wetland.

The flocculant testing discussion in section 4.8.1 states: "It is anticipated that fourteen floc logs will be placed....one floc log per 40 gpm (assuming a discharge flow rate of 560 gpm)." What is the significance of the 560 gpm flow rate relative to scale-up considerations? Is AR suggesting that this would be a design flow rate for a full scale system?

The surface flow wetland is dependent on plants for effective operation, but plant survival over winter 2013/2014 may be limited because the wetland is being installed late in the growing season. This could make evaluation of the effectiveness of a surface flow wetland difficult in time for final water treatment technology selection in 2014.

<u>Sulfide Precipitation Unit</u>

The scientific basis for changes in the SSF design relative to the pilot wetland design should be carefully considered to ensure that changes made to improve flow characteristics will not adversely impact the effectiveness of the sulfide precipitation, the key component of the wetland demonstration project. For example, reducing the manure content by ½ may be effective in reducing hydraulic control problems such as preferential flow paths or settling, but the effect on startup time, effectiveness, or lifetime of the treatment system is unknown. Reducing the manure may demonstrate an improvement in the cell hydraulics, and short-term performance may prove effective, but this deviation from standard practices used with sulfate reducing systems is not supported by any data presented in the pilot-scale results or this Work Plan.

The basis for the use of large wood chips, beyond the need to promote hydraulic conductivity in the SSF, should be stated. It would be helpful to have a reference that shows that added surface area from using smaller wood chips or woody material with more surface area isn't needed for effective long-term treatment and that the larger materials won't adversely affect treatment efficiency over the lifetime of operation.

A monitoring system will be set up to monitor $H_2S$ released from the SSF wetland. Section 4.4 states that the one of the objectives of the aeration channel evaluation is to quantify $H_2S$ gas generation sources, rates, and mitigation methods; however, it is important that the evaluation also include the SSF wetland. More information is needed to evaluate how this will be accomplished.

Three types of precipitate (Al, Fe, Mn)/armoring and the effects on different parts of the system and connections within the system need to be discussed in greater detail. Armoring by certain metals is a likely development in a longer-term study, which the current planned duration may not result in.

One of the main issues with a passive treatment system is plumbing, including connections and valves and the ability to clear, flush or replace failed lines and connections; provide in the Work

Plan the details describing how the design allows for this contingency. Because of the short time-frame of the demonstration scale testing, plugging may not occur, but over-time in a full-scale metal-precipitating system with the barrier design, there is a good possibility plugging will occur, and maintenance would be difficult without stopping flow. EPA has observed this condition is systems installed in other mine water SRB based treatment systems.

Sulfur Prill

The Work Plan does not explain the rationale for addition of sulfur prills. Results from the pilot wetland show reduction in metals concentrations, dissolved oxygen, and oxidation-reduction potential, indicating sulfate reduction is occurring, but a parallel reduction in sulfate concentration was not observed. Thus it appears, but is not proven, that the bacteria prefer to degrade the prills rather than use the sulfate in the water for sulfate reduction.

Since monthly water quality sampling began in April 2011, $SO_4$ concentrations at DR-3 have ranged from approximately 550 mg/L to as great as 976 mg/L. These concentrations are adequate for sulfate reduction, based on experience with other SRB systems. Determine if the prills are needed for effective metals removal and what benefits may be realized by prill addition (e.g., reduced reactor size, improved metals removal efficiency). Eliminating the use of prills could lower system costs, extend the substrate lifetime, and likely reduce the sulfate load to the Dolores River, thus the benefits of prill addition should be determined before requiring them in a full scale system.

The potential effects of adding sulfur prills on $H_2S$ generation should be discussed and a justification provided for this addition. At this time, it recommended that sulfur prill not be added to the system

Rock Drain

Evaluation of the pilot-scale reactor concluded that despite colder than hoped for temperatures, the rock drain functioned adequately. Moving the rock drain to be the fifth component of the treatment train, after the settling basin, aerobic wetland, anaerobic wetland, and aeration channel could cause the temperature factor to be more problematic, especially with the last portion of the aeration channel (upstream of the rock drain) causing vigorous mixing with air. Given the current configuration, the rock drain could be located as far south as current Ponds 5 and 6 in a full-scale system. Geothermal water that enters the downstream ponds might slightly mitigate the temperature issue, but a review of the winter temperature measurements made during monthly water quality sampling events shows water temperatures generally (but not always) decrease between the inflow to Pond 7 (DR-5) and the discharge from Pond 5 (DR-6).

One of the objectives of the rock drain portion of the study is to "determine the effects of rock size, shape, and type on hydraulic residence time, hydraulic conductivity, and treatment performance over time." It is unclear how this will be evaluated when the rock size in the rock drain appears to be uniform throughout.

Required Land Area

The overall area of the demonstration wetland system, using the "matrix surface" dimensions (not including other needed features) are as follows:

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| Settling basin | 75'x21' | 6 feet deep |
| Surface flow wetland | 54'x25' | 1 foot deep |
| Subsurface flow wetland | 47'x70' | 4.8 feet deep |
| Aeration channel | 62'x2' | 0.75 foot deep |
| Rock drain | 117'x32' | 3.4 feet deep |

This correlates to a total area of 10,083 $ft^2$ (0.23 acre) for a 30 gallon per minute (gpm) design flow, not including berms, support structures, and other support features such as roads. Assuming linear scale-up, 9.2 acres would be needed for a design flow of 1200 gpm, and significantly more area would be needed to include support other site features.

As part of this Demonstration Scale evaluation and other investigations at the site, the significance of the presence of groundwater that may limit the depth of the wetland system needs to be evaluated.

It is possible that the flatter topography at the south end of the site may affect the ability to install adequate aeration channels, if needed.

**Additional Comments**

Calculations are not shown for the hydraulic residence times listed in Table 2, and the hydraulic residence time of the SF wetland is not stated. Correct calculation of the effective residence time is of particular importance for the SSF wetland, where the time water spends in reducing conditions is a key parameter for ensuring adequate metals concentration reduction.
There is no mention of food for the bacteria colonies in the rock drain.

Plans for specific test parameters, sample timing, and data reduction should be provided in the PMP, and the PMP must be submitted to EPA by October 7, 2013.

With the significant financial and time investment that is being made in the demonstration wetlands project, it is likely that AR will want to monitor the wetland beyond the decision deadline for water treatment conceptual design, perhaps as part of regular water quality monitoring.

Please provide a written response to these comments by October 9, 2013 and a revised Work Plan to follow.

Sincerely,

Steven Way,
On-Scene Coordinator

cc: Amelia Piggott, 8ENF-L